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Making or breaking the business case of digital transformation initiatives: the key role of learnings

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ABSTRACT

Purpose: The research aims to investigate how firms can develop their sensing capabilities for Industry 4.0 (I4.0) technology adoption through reframing their opportunity perceptions related to learnings from I4.0 initiatives.

Design/methodology/approach: The research follows a design science research (DSR) approach. Following the case of I4.0 technology introduction at a large food manufacturer, the paper develops a theoretical framework (artefact) and validates the applicability and efficacy of the framework within the case study.

Findings: The theoretical framework highlights the different temporal (short-term/long-term) and locational (direct/indirect) value dimensions of I4.0 opportunities. The findings show that the use of the framework can shift managers' perception regarding the business value of an I4.0 technology implementation. Specifically, the framework reversed initially negative perceptions around a narrowly scoped business case toward an opportunity-oriented attitude exploring further potentials of the technology.

Research limitations/implications: The research adds to the debate when and why firms engage in, and sustain their I4.0 initiatives by providing a novel perspective on firms' sensing capabilities. As a single-case study, the framework requires further validation in practice.

Practical implications: The proposed framework provides practitioners with an extended view concerning the potential value of digital transformation projects and serves as a conversational tool.

Originality/value: The presented wider frame for evaluating digital transformation projects, taking into account the more "intangible" value of their learnings, tackles the fundamental issue of translating explorative innovation efforts into exploitative value - a key challenge when dealing with innovation and one of the main barriers for the digital transformation.

Keywords: Industry 4.0, Innovation, Knowledge mapping, Learning, dynamic capabilities.

1. Introduction

In recent years, the Industry 4.0 (I4.0) agenda and the related integration of digital technologies in the manufacturing domain have seen rapid growth (Liao et al., 2017; Ortt et al., 2020). This "industrial digital transformation" promises to generate value through the achievement of operational excellence and by catalysing new, digitally enabled business modes (Kagermann et al., 2013).

As such, I4.0 represents a paradigm shift that requires substantial rethinking of business models (Arnold et al., 2016), supply chain organization (Hermann et al., 2019), and/or customer relations (Frank et al., 2019). In other words: a radical change of perception regarding when and how business value is created (Müller, 2019). Yet, despite claims of policy makers and consultancies regarding the benefits of adopting I4.0 technologies, research evidence on unequivocal, positive effects of I4.0 on operational performance or other value creating areas is still scarce and scattered (Kagermann, 2015; Müller and Voigt, 2018; Szász et al., 2020). More so, investigations in *how* business value is created or increased through adoption of I4.0 technologies reveals a complex picture of interlinked, and interdependent effects (Ghadge et al., 2020) and contingencies (Ghobakhloo and Fathi, 2019). Facing such high level of complexity in a widely novel domain, many managers and executives are doubtful about the positive business case for I4.0 technologies in general (Pirola et al., 2019; Schmitz et al., 2019), or specific applications such as Industrial Internet of Things (Müller and Voigt, 2018). Recent surveys by leading consultancy firms argue that the resulting uncertain prospects of benefit realization from I4.0 technologies posit a key obstacle for digitalization initiatives across manufacturers (PWC, 2018; Schmitz et al., 2019).

Research found that successful I4.0 adopters share a particular mind-set that enables them to venture into such uncertainties. Authors described such firms as 'entrepreneurial' or exhibiting a 'start-up mentality' (Veile et al., 2020), as focussed on innovation (Müller et al., 2018), or as characterized through enhanced 'sensing capabilities' (Demeter et al., 2020; Teece and Linden, 2017). The underlying denominator of such successful adopters is thus their opportunity-orientation, focusing on understanding, exploring, or discovering the potential of the technology (Bordeleau and Felden, 2019; Erol et al., 2016). Yet, such research merely illustrates that an opportunity-oriented attitude is a capability of successful I4.0 adopters, but stop short on exploring how such capabilities emerge or can be fostered. Our research therefore asks: *How can manufacturers develop an opportunity-oriented perspective for the adoption of Industry 4.0 technologies?*

To explore this question, we consider opportunity-orientation akin to the sensing capability in Teece's (2007) dynamic capabilities framework, as a capability that firms can deliberately develop. For the research we thus explored behavioural interventions designed to change attitudes and perceptions of top managers, following a Design Science Research (Hevner et al., 2004) approach. Specifically, we developed a framework to guide conversations about I4.0 initiatives in a manner that addresses opportunities that stretch beyond the direct and short-term impact of a specific technology project – thus reframing the management team's perception of innovation's categorical boundaries (Raffaelli et al., 2019). We tested the designed intervention with a large Scandinavian food manufacturer and observed important changes in managerial conversations about the technology, namely through an increased discussion of future potential value.

We thereby contribute to the growing literature on I4.0 implementation as a process that is contingent on organizational and social developments, as much as on technical factors (Cimini et al., 2020; Frank et al., 2019). Specifically, we provide empirical insights how manufacturers can hone their sensing capabilities through deliberate shifts in conversational patterns. For practice, we present an easy to implement conversational tool that enable these shifts in conversations toward an explorative and opportunity oriented perspective on the business value of a specific technology.

2. Theoretical foundation

The Industry 4.0 (I4.0) agenda promises huge potential for transforming the manufacturing industry by increasing efficiency, improving decision-making, and opening up novel ways for value creation and business model innovation (Kagermann et al., 2013). Yet, many manufacturers seem hesitant in adopting I4.0 technologies (e.g. Moeuf et al., 2018; Müller and Voigt, 2018; Pessot et al., 2020). Thus, research places increasing attention to the questions which types of enterprises venture into digital transformation, and what characterizes those, that succeed (Ortt et al., 2020).

These questions shifted attention toward the interaction of technology with its social and organizational context (Frank et al., 2019) and increased attention to the procedural nature of I4.0 adoption. Recent research has characterised I4.0 adoption as co-evolution of organizational structure and technology (Cimini et al., 2020), as organizational learning paths (Tortorella et al., 2020), or as transformative organizational change processes (Erol et al., 2016). Several authors suggested that dynamic capabilities theory is a suitable lens to explore and explain these processes (Demeter et al., 2020; Ketonen-Oksi and Järvi, 2018; Teece and Linden, 2017).

2.1. Industry 4.0 adoption as expression of dynamic capabilities

Dynamic capabilities theory (Teece, 2007; Teece et al., 1997) provides a frame to study strategic reconfigurations of firms in rapidly changing contexts, such as the development of the I4.0 agenda. Teece (2007) suggests three types of interacting dynamic capabilities – sensing, seizing, and transforming – as characteristic of firms that achieve competitive advantage in dynamic environments. This framework has recently been applied to study firms that successfully adopted I4.0 technologies (Demeter et al., 2020; Ketonen-Oksi and Järvi, 2018; Teece and Linden, 2017). Additionally, Bordeleau and Felden (2019) argue in their review of I4.0 literature, that models of organizational change for digital transformation mirror the dynamic capabilities framework (**Error! Reference source not found.**).

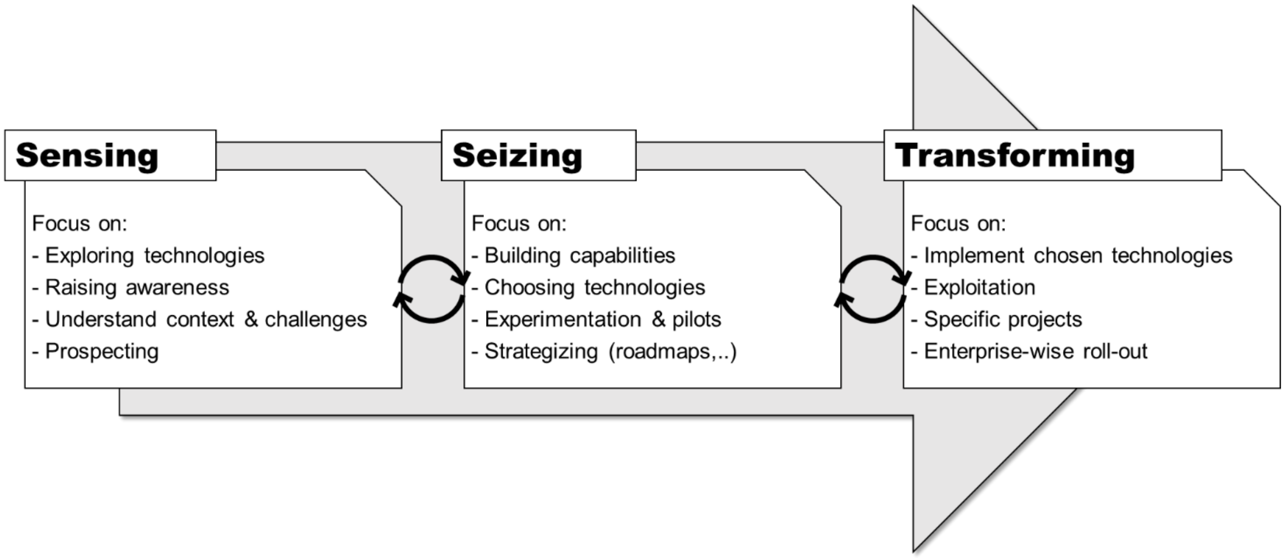

Figure 1 - Digital Transformation as interacting dynamic capabilities (adapted from Teece and Linden, 2017 and Bordeleau and Felden, 2019)

A particular focus of the literature on I4.0 adoption through a dynamics capabilities or organizational change lens rests on sensing capabilities, in other words, a firm's capability to sense and shape opportunities by scanning and interpreting their context, and creating novel modes to engage. Erol et al. (2016) describes a phase of 'envisioning' in which companies acquire technological and application knowledge through external experts, and interpret this new knowledge as a contextualized vision for their digital transformation through internal discussion, collaboration, or co-innovation. Ketonen-Oksi and Järvi's (2018) action-based research on future-orientation highlighted the role of perceiving, and in consequence prospecting opportunities related to adoption of new digital technologies. Less concerned with the micro-foundations of sensing capabilities, Horváth and Szabó (2019) concluded that SMEs, which are less able to identify opportunities from digital technologies, lag behind in I4.0 adoption. Conversely, other research found that enterprises that have adopted I4.0 exhibit an opportunity-oriented "entrepreneurial spirit" (Veile et al., 2020) and are more oriented toward innovations (Müller et al., 2018). Demeter et al. (2020) thus conclude that sensing capabilities play a – if not always dominant – yet essential role for all stages of digitalization in manufacturing, with the "[m]anagers' perceptions [as] the main drivers of sensing capability" (p. 6).

Such insights align with general concepts from strategy and innovation management, which highlight the importance of reframing the management team's perception of innovation's categorical boundaries (Raffaelli et al., 2019; Tushman and Anderson, 1986) to explore opportunities beyond the existing systems. Thus, sensing capability, understood as the capability to perceive, envision, or prospect opportunities related to novel digital technologies, is arguably a central factor for enabling digital transformation. Yet, as we will highlight in the next section, I4.0 opportunities are – akin to the uncertainty and complexity of any radical innovation (Cooper, 2011) – multifaceted, complex, and often not obvious.

2.2. Opportunities of I4.0 – complex patterns of business value generation

The I4.0 literature uses the term opportunity widely (Horváth and Szabó, 2019), referring to a plethora of themes, from new business models (Frank et al., 2019; Müller et al., 2018), over increased innovation capacity (Lasi et al., 2014), to performance improvement (Kiel et al., 2017). What ties those ideas together is the notion that I4.0 technologies promise the potential to maintain or increase business value in the future. We thus define opportunity for our purposes as an *uncertain prospect of positive effects on business value*. Following March (1991), we consider such opportunities as both exploitative, building on old "certainties", and explorative, engaging new possibilities. Opportunity-orientation, in turn relates to the organization's ability to continuously explore, identify, articulate, and exploit such opportunities.

Several authors provide a cautious view on how and when such positive effects on business value can be expected (Kagermann, 2015; Müller and Voigt, 2018). For example, Ghobakhloo and colleagues (Ghobakhloo and Azar, 2018; Ghobakhloo and Fathi, 2019) have challenged the – possibly naïve – notion that there is a direct link between digitalization and business performance, pointing to enabling and impeding contextual factors of the organization, such as organizational structure or pre-existing IT capabilities. Moreover, studies into the causalities of business value creation through digital technologies, such as Ghadge et al. (2020), highlight the complex dynamics through which individual or coupled new digital technologies affect business value. Other studies, such as Cimini et al.'s (2020), point to the co-evolving nature of technology and organizational factors that enable its value creating deployment. Thus, I4.0 opportunities appear as a complex narrative of dynamically interacting technological, organizational, and human components (Dregger et al., 2018; Oks et al., 2017) – often changing not only tasks, roles and processes through technology, but also rooting deeper in changed business models (Frank et al., 2019; Müller, 2019) or organizational identity (Wessel et al., 2021).

These complex and dynamic interactions render I4.0 opportunities uncertain in three aspects: (1) Expected outcome, (2) Temporal scope, (3) Application scope.

(1) Expected outcome: The complexity through which digital technologies may interact with numerous technical, organizational or strategic elements of the organization (Ghadge et al., 2020) limit the possibilities to predict the impact of the technology on performance in specific application areas. Overwhelmed by the vast number of potential technologies, organizations moreover struggle in selecting those that might be most favourable for the specific problem and context (Bosman et al., 2020). Finally, as a still "young" agenda, organizations lack experience to make reasonable assumptions about the potential expected outcomes. Consequentially, managers often lament the unclear business case for a specific technology (Schmitz et al., 2019), or cannot perceive clearly the economic benefits of an I4.0 initiative (Pirola et al., 2019).

(2) Temporal scope: Digitalization processes often pass through an extended phase of exploration and experimentation with no immediate contribution to business performance (Erol et al., 2016; Ganzarain and Errasti, 2016). The exploitation of the technology with direct benefits to conventional measures of operational performance thus follows

only years after the initial exploration of the technology (Szász et al., 2020). Thus, digitalization processes are uncertain regarding when they will generate business value.

(3) Application scope: With the wide reaching implications of novel digital technologies on tasks, processes, structures, and business models, the value generating potential of any such technology is typically not bound to a singular application area. Longitudinal studies on I4.0 adoption in single organizations, such as those by Demeter et al. (2020) or Cimini et al. (2020), illustrate how organizations over time identify additional and unexpected application areas for a specific technology. Innovation studies recognize such "application richness" as potential for further innovation in other domains, enabled by the learnings from the initial experimentation with the technical innovation (McGrath, 1997; Rice et al., 2001). Additionally, learnings from experimentation with I4.0 innovation can supporting further innovation activities at a higher maturity level and, hence, the progression of an organization towards more long-term strategic goals such as servitization. However, the specific potential for extended application, and which of these applications eventually will contribute to business performance and value, are uncertain at the outset of the I4.0 journey.

Taken together these uncertainties make the adoption of I4.0 a risky undertaking, which may impede the willingness and ability of companies with less resources to take these risks (Bosman et al., 2020; Buer et al., 2020). Yet, such a conventional risk/benefit perspective on digitalization technologies is unlikely to be suited for adoption decisions around novel I4.0 technologies. Connecting back to the idea that I4.0 adoption requires sensing capabilities, grounded in exploration, experimentation, and prospection, organizations may be better advised to embrace and open-mindedly investigate these uncertainties (Ketonen-Oksi and Järvi, 2018), than rationalizing them through conventional business cases. In the following, we will develop a theoretical framework that may enable such a focus shift by expanding the vision beyond a narrow project business case. Thereafter, we report on the effects of the application of the framework in a real-world digitalization initiative.

3. RESEARCH APPROACH

Teece (2007) argues that firms can develop and hone their dynamic capabilities. Thus, our research approach is interested in interventions through which firms can develop their sensing capabilities. To structure the development of such theoretically grounded interventions, ensuring both their academic rigor and practical relevance, we adopted a design science research (DSR) framework (Hevner et al., 2004). This research approach aims at supporting researchers in the generation of instrumental knowledge – such as theoretical frameworks - intended for helping practitioners in addressing empirical problems (Boer et al., 2015; Boyer and Swink, 2008; Holmström et al., 2009; van Aken et al., 2016) such as the one we are addressing.

The DSR framework structures the research process as starting with a novel and relevant pragmatic problem coming from the environment. The first phase of this research process is abductive: the researcher aims at solving the initial problem taking advantage of existing knowledge and, due to its novelty, introducing a creative element. This is expected to lead to the generation of "new knowledge", under the form of artefacts, such as a new theoretical framework. The second phase is deductive, validating the proposed artefact through tests in practice (Hevner et al., 2004; Holmström et al., 2009; van Aken et al., 2016).

The research took place as a single case study in a Danish-based multinational food manufacturer. The firm experienced issues with the rollout of a digital transformation project, connected to a perceived unclear – if not negative – business case when assessing the initiative only regarding the specific addressed issue. The case company thus is illustrative for investigating the phenomenon of unclear business cases as barriers to I4.0 adoption (Pirola et al., 2019; Schmitz et al., 2019), making it a suitable example for developing and testing the artefact. As a phenomenon that is relatively novel in academic discourse and deeply entangled with its organizational context, a single case study is thus an adequate research approach (Yin, 2009) despite its limitation in generalizability. Specifically, the close collaboration with the firm allowed developing rigorous problem understanding and analysing the effect of the artefact in detail.

We used only primary data from our direct and continuous observations from the digitalization project. Two researchers collaborated with company practitioners on the development of the technical innovation, where they collected data on main discussions and events surrounding the project on a continuous basis in two research diaries. Additionally, these two researchers documented two workshops with a wider stakeholder participation through independent notetaking. Supported by a third researcher without affiliation to the company and project (an "outsider" according to Fetterman, 2010), the research team continuously reviewed and discussed the collected data to ensure completeness and to align a common understanding of the collected observations. Based on the collected data, the research team discussed how the company practitioners discussed and perceived opportunities associated with the innovation, and – through iterations between literature and our observations – thus developed the framework intended to create opportunity orientation in their discussions. We validated our emerging framework through confrontation with all involved stakeholders during the course of the project (Yin, 2009). This happened through ongoing discussions of the findings with key actors of the digitalization project.

For our framework building, we started with a fundamental assumption: learnings obtained from explorative innovation initiatives can be applied elsewhere, and through their application in other contexts, these learnings may increase the value of the original initiatives. By shifting attention toward the value of learnings and long term value of an explorative innovation, we would expect that decision teams could better appreciate the potentiality for value creation, thus increasing their capability to sense opportunities associated with the innovation. To operationalize and test this fundamental assumption, we wanted to develop and test a framework that facilitates identifying and formulating future business opportunities (the exploitative potential) related to learnings obtained during an explorative project. The development of the theoretical framework subsequently connected elements of uncertainty concerning I4.0 opportunities with insights from the innovation literature for facilitating the identification of novel business opportunities. We iteratively developed first elements of the framework, specifically the locational and temporal dimension of I4.0 opportunities, and then aggregated them in our two-dimensional framework ('digital transformation focus-shift matrix')

To validate the theoretical framework in its context, we defined two validation criteria: (A) Applicability: Does the theoretical framework enable the identification of business opportunities related to an innovation project? (B) Effectiveness: Does the use of the theoretical framework lead the company towards increased support for digital transformation initiatives? The Applicability criteria (A) required that the framework can be applied in its entirety in an industrial setting, specifically that all involved stakeholders can understand and independently adopt the framework and its underlying concept. The effectiveness criteria (B) requires that the adoption of the theoretical framework can shift the perception of the involved stakeholders regarding the innovation project's business case, i.e. considering not only one, but a multiplicity of opportunities related to the digital transformation initiative.

We validated the framework in the course of two workshops involving all the stakeholders that previously took part in the innovation project (including the researchers). During the first workshop, the researchers presented a mapping of learnings from the digitalization initiative. The stakeholders first discussed those proposed learnings, and explored, second, their potential applicability in the company against the two dimensions of the framework – locational and temporal. In the second workshop, the involved stakeholders discussed against the dimensions of the framework how the additional applications of such learnings and the related business opportunities were affecting the business case of the innovation initiative. We used observations from the workshop, and post-hoc reflections of stakeholders on the workshop to assess the validity of the framework against the defined criteria of applicability and effectiveness.

4. DEVELOPING THE DIGITAL TRANSFORMATION FOCUS SHIFT FRAMEWORK

In section 2, we have established that opportunities of I4.0 technologies are uncertain regarding their outcome, their temporal scope, and their application scope. In consequence, the potential business value of a novel technology – and the costs associated with capturing such value – are difficult to assess by means of conventional business cases. Hence, instead of merely expanding the business case template by new metrics, we suggest that decision-makers require a fundamental focus-shift to judge the overall potential of a specific I4.0 technology – a shift toward opportunity-orientation that potentially enhances their sensing capabilities. In the following, we develop a theoretical framework for such a focus-shift.

According to the DSR framework, adopted in this research, our framework addresses a practical issue by building on extant knowledge. More specifically, we build on the previously identified types of uncertainty of I4.0 adoption opportunities and insights on value generation from the innovation literature. Thus, we first introduce different value categories associated with innovations, and map them against the uncertainties of I4.0 adoption. This allows us to introduce novel perspectives on locational uncertainty (Where is value generated?; Figure 2) and temporal uncertainty (When is value generated?; Figure 3). Finally, we combine these two uncertainty dimensions by outlining a progression that enables a holistic business case evaluation (Figure 4).

4.1. Categories of value generation through innovation

Business opportunities related to I4.0 innovations expand beyond the mere adoption of an innovation to solve specific and well-defined problems (Cimini et al., 2020; Demeter et al., 2020). Innovation management literature suggests that innovation provide additional value, on one hand, through its potential application to address additional issues (Bowman and Hurry, 1993; McGrath, 1997; Rice et al., 2001) and, on the other, its use to catalyse and support further innovation (Rice et al., 2001).

Reflecting these insights against our observations in the case, we defined three distinct "value categories" to compose our theoretical framework. Each value category represents one aspect how innovation initiatives and the related learnings can create business opportunities. These are:

- Problem solving: The ability of the digital transformation initiative to effectively address the initial problem which triggered it;
- Extended potential: The potential applications of the digital transformation initiative – or of its learnings – to address other problems, either supporting the pursuit of the original performance objective or generating value in other directions;
- Innovation: The use of the learnings obtained through the digital transformation initiative to support further transformation initiatives, possibly aligned with a company's strategic direction and goals, acting as a foundation for maturity growth.

4.2. Localization of value: the concept of business case ecosystem

Following the outlined value categories, we conclude, in accordance with the idea of localization uncertainty, that the benefits of such projects often materialize well beyond the original scope. Thus, the localization and attribution of value require contextualization of the innovation project in its wider environment.

To enable such contextualization, we propose the use of the ecosystem analogy, increasingly popular in innovation studies (Gomes et al., 2018). The ecosystem view aims to capture value creation stretching beyond the original organizational boundaries (Kapoor and Lee, 2013). For example, Venkatraman et al. (2014) conceptualize digital business innovations as pertaining to platforms of initiatives and actions within and across organizations. In the same way, we argue that digital transformation initiatives typically are set up within specific boundaries, such as defined purposes, budgets, teams, schedules, and the like. Nevertheless, such initiatives heavily interact with their environment, through social relations, the use of shared resources, the use of knowledge, and so forth. Moreover, any digitalization project is likely to contribute to broader strategic programme capturing numerous organizational initiatives (Ghobakhloo, 2018). Thus, we can consider even purely intra-organizational digital transformation projects as pertaining to an ecosystem of other projects with individual business cases.

Using the ecosystem analogy (Figure 2), we thus can extend the value propositions included in the business case of a digital transformation project. On one hand, value can then be direct, addressing the issues and the performance objectives that triggered the digitalization project and the development of a solution (thus considered in the conventional assessment of a business case). On the other hand, value may be indirect, or addressing additional issues and contributing to different performance objectives, but still generating valuable effects beyond such localized boundaries. Indirect value could have either a mono-directional or a dynamic relation with the developed solution: take advantage of the solution and, potentially, providing inputs to catalyse its further development.

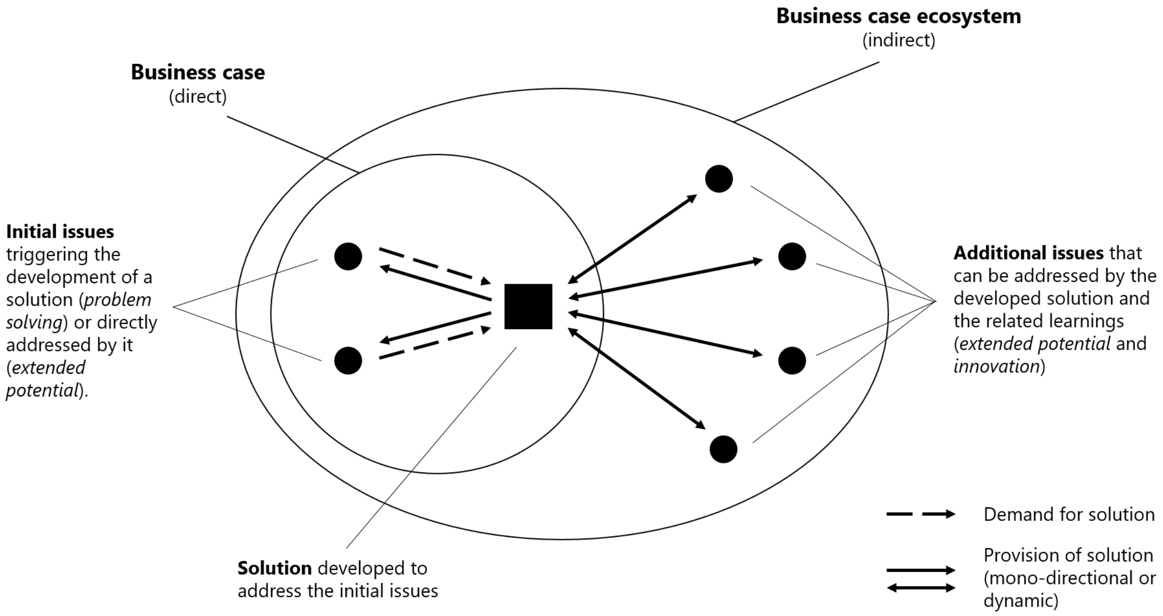

Figure 2 - Local dimension of value in innovation initiatives: The business-case ecosystem

While indirect value can have tangible financial effects in terms of efficiency increases, cost savings, and so forth, they are often not present in the initial evaluation of an innovation project, or even fully realized at the end of a project. Hence, to evaluate the value of a digital transformation project in its entirety, the appraisal needs to capture both the direct and the indirect value related to the project. Thus, to argue for its business case, the discussion should reflect a whole spectrum of projects and related improvements that may benefit from the learnings obtained from the initiative. We argue that the adoption of this ecosystem perspective would, most likely, support the perceived economic feasibility of digital transformation projects.

4.3. Timing of value: the temporality of innovation projects

Radical innovation – such as I4.0 technology adoption – often has year-long cycle times, leading to substantial time-lags between deployment of the innovation and value capture, and unclear value paths linking the innovation and later captured business value (Paulson et al., 2007). Thus, in a context where most conventional projects are appraised based on hard metrics such as return on investment, the lagging value of innovation projects becomes harder to discern. In the manufacturing domain, with relatively stable conditions, the temporal focus is highly skewed towards the exploitative, short-term perspective (March, 1991; O'Reilly and Tushman, 2013). This focus manifests through an orientation towards continuous improvement. Yet, digital transformation as a radical innovation may require more time due to their (often) explorative nature.

To enhance an organization's ability to appraise the value of a digital innovation holistically, interventions, thus, need to tackle time directly. By changing the temporal perspective, innovation projects are not *either* short-term, measurable and predictable, *or* long-term, fuzzy opportunity engines, but often both. Consequentially, our theoretical framework is designed to take into account the temporal dimension and relates it to the different value categories (Figure 2).

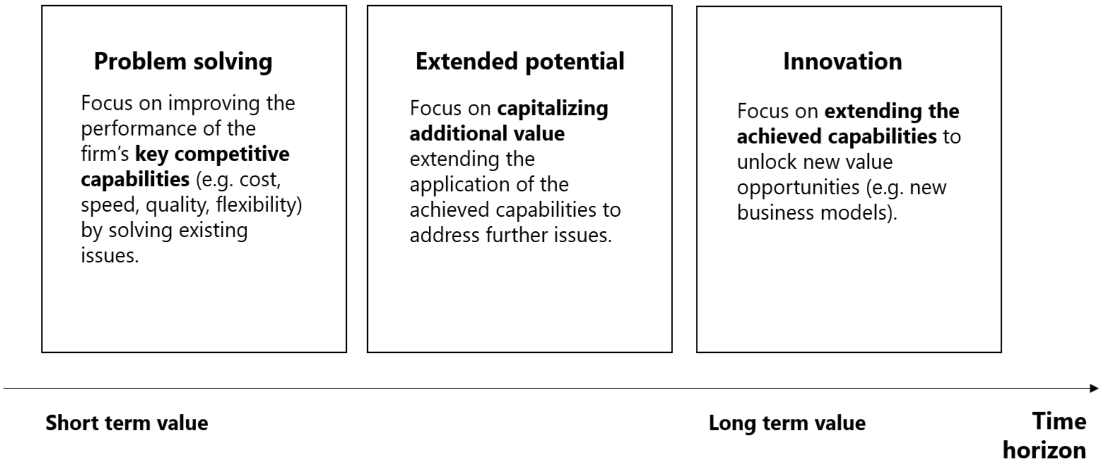

Figure 3 - Temporal dimension of value in innovation initiatives

In summary, we argue that an innovation project may start from a well-defined problem, but can end up looking (and bringing value) further in time. However, looking further requires a different understanding of value as something that is not necessarily measurable just yet. Therefore, to holistically appraise an innovation project, decision-makers need to consider both the short-term effects on known issues and the potential long-term effects of future opportunities – whether know or unknown - generated through the innovation project.

4.4. The digital transformation focus-shift matrix: going beyond problem solving

Taking into account the three value categories we proposed and relating them to the two dimensions– temporality and localization –, we can outline a matrix, which is describing our digital transformation focus-shift framework and, more specifically, how the managerial focus can shift beyond problem solving (Figure 4).

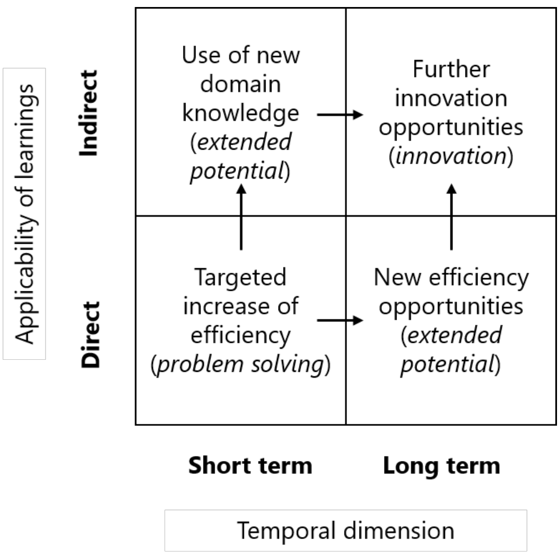

Figure 4 - Digital transformation focus-shift matrix

Starting from the initial problem solving focus, typical for innovation projects directly targeting a specific performance objective and the increase of efficiency in its regards, we suggest three additional value areas. These concern the application of the learnings obtained through the digital transformation project for capturing additional value, either directly or indirectly and either in the short- or long-term.

The use of *new domain knowledge* relates to the foreseeable, short-term application of the learnings - obtained during the digital transformation project from extensively working, for instance, with a specific technology - to address other issues and different performance objectives. As this would not contribute to the improvement of the specific performance objective that initially triggered the project, the related business opportunities are only indirectly supporting the business case of the digital transformation initiative. Nevertheless, it is worth considering that such support is obtained through the deployment of learnings (e.g. technological or organizational capabilities) that have already been obtained and, therefore, does not require further development investments.

The *new efficiency opportunities* relate to initially unknown value creation potentials emerged from the digital transformation project (and from working with the addressed issue) and with an effect on the initially targeted performance objective. While these may require further development of the obtained learnings to capture such new efficiency opportunities – hence a long-term horizon – it would also directly support the business case concerning the digital transformation project.

The *further innovation opportunities* concern the role of the obtained learnings in acting as a building block for generating further and more complex learnings, increasing the digital maturity of the company and making it possible to tackle more (e.g. technologically) advanced and ambitious projects. On one hand, the development and use of new domain knowledge act as a starting point for further innovation. The recognition of novel issues to be addressed with the obtained learnings may provide inspiration for further innovation, highlighting new potential problems to be addressed and directing the innovation path towards them. On the other hand, the identification and capturing of new efficiency opportunities as it drives the further development of the obtained learnings facilitates the innovation progression (i.e. by progressively extending technological or organizational capabilities). If to be captured, the value of further innovation opportunities is certainly linked to a long-term horizon. This would make it an indirect contributor to a digital transformation project's business case. Nevertheless, such value contribution is certainly challenging to quantify. While organizational decision-makers may be aware of past examples, these do not provide a robust indication of value magnitude of future business opportunities. If this makes their potential value less tangible, it is also true that to continuously pursue them remains crucial for the digital maturity progression of a company – ultimately for its digital transformation (Colli et al., 2019a).

We do not intend this theoretical framework as a template for business case appraisal for digitalization projects, but rather as an enabler for organizations to review and adapt their current practices of project appraisals. By identifying how they reflect different value categories in their practices, processes, and routines, they can consciously shift their focus allowing more balanced evaluations of digital transformation projects.

5. Artefact Development in Context

Following the DSR framework (Hevner et al., 2004), we iteratively developed and validated the proposed theoretical framework in an industrial setting against the validation criteria we preliminarily specified (applicability and effectiveness, as defined in Section 3).

5.1. The industrial case

We developed the theoretical framework in the context of a Danish-based multinational organization, operating worldwide in the food sector. In collaboration with a Danish technology provider and Aalborg University, the company started a digital transformation project with the intention to reduce its operational costs. This project had been preliminarily scoped by the company around the loss of transport grates, metal structures on wheels used for collecting and transporting products within and outside company premises. The quantity of lost transport grates had a significant impact on operational costs, both directly – related to the need for buying new grates – and indirectly – related to production efficiency loss due to their unexpected unavailability. The main hypotheses regarding the nature of the issue were (1) that these grates were forgotten on the outskirts of customers' warehouses and (2) that competitors were using these grates for their own external or internal logistic activities.

The project stakeholders agreed to address the problem investigating the development of an IoT based solution capable of tracking them and, more importantly, of providing the company with data about their location. This need for transparency across the company's supply chain implied the availability of data concerning both the identity and location of each transport grate. This would give the company the chance to both quantify the temporarily unavailable grates, regulating production processes accordingly, and to identify and locate the "lost" ones. A key success requirement for the project and the to-be developed IoT solution was, in addition to its effectiveness in addressing the problem (i.e. problem solving; Figure 5), the presence of a positive business case.

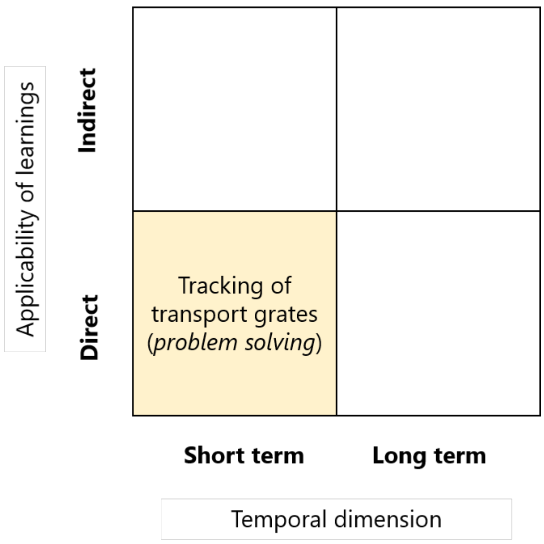

Figure 5 - Initial digitalization initiative focus

The digital transformation project has been structured around an agile approach based on design thinking and divided into two demonstration cases (i.e. iterations). The second demonstration case was intended as a chance to refine the solution developed in the first one – if successful – or to develop a different solution – if not.

The two demonstration cases involved two company representatives (i.e. digital strategy manager and plant manager), responsible for the provision of case-specific information, four engineers – including the project manager - from an external technology provider, responsible for the provision of technical knowledge and for the technical development of the solution, and two researchers (i.e. two of the authors of this paper) engaged in the Industry 4.0 agenda, responsible for the provision of knowledge concerning innovation, operations and supply chain management.

5.2. Problem solving and the business case challenge

The first demonstration case led to the development of a solution that involved the deployment of GPS sensors transmitting data over Sigfox (i.e. a communication service) in order to track the transport grates across the company's supply chain and making it possible for the company to reach out to the ones that had not been returned. The solution successfully addressed the initial issue by generating visibility concerning the transport grates' location. In addition to that, its testing verified the initial hypothesis concerning the illegal use of transport grates by competitors. However, even assuming a 100% reduction of the transport grates loss, the cost of the proposed solution was perceived as too high.

The second demonstration case was, therefore, focused on the development of an alternative solution, based on a cheaper technology. The technology provider suggested Bluetooth 5.0 and 5.1 (BT5.0 and BT5.1) due to its lower cost, combined with Node-Red (i.e. a cloud platform) for processing and visualizing the collected data. However, due to the characteristics of the selected technology (i.e. shorter data transmission range), the second demonstration cases focused on tracking transmission grates within the company's premises. This enabled the provision of a count of the available ones, addressing the indirect cost caused by the loss of transport grates (i.e. production efficiency loss). While it was not possible to quantify it due to the lack of data, the estimated business case concerning the solution developed in the second demonstration case was still perceived as negative.

The involved management representatives considered the performed digital transformation project as not successful from a financial perspective: it did not convince the company stakeholders to implement the developed solution. If the developed solutions were capable to address the problem effectively, the perceived value potential was not enough to justify the investment. Nevertheless, the project generated a number of leanings.

5.3. From learnings to business opportunities: shifting the focus towards extended potential and innovation

To explicate the learnings obtained from the project, and thus be able to reflect upon their potential value, we initially mapped them, isolating the single functions that the developed solutions were able to perform. These concerned:

- The automatic tracking of the grates, including identity and location data (i.e. using GPS technology outside the company – demonstration case 1 – and BT5.0 and 5.1 technology inside the company – demonstration case 2)
- The automatic transmission of tracking data within or outside the company (i.e. through Sigfox for GPS sensors or Node-Red for BT5.0 and 5.1 sensors)

- The analysis and visualization of tracking data to provide information concerning the identity and location of the tracked grates (i.e. Node-Red)

We presented these learnings to the involved stakeholders during a first workshop - to be validated - after presenting them the “digital transformation focus shift” theoretical framework. The workshop participants discussed the potential applications of the learnings in a brainstorming session, taking into consideration the different value categories included in the framework and the related value applicability and temporality aspects.

The discussion initially concerned the use of the learnings to address additional issues (i.e. extended potential). On one hand, these represent well-known issues indirectly affecting the performance objectives and that could have been immediately addressed (i.e. in Figure 6: use of new domain knowledge, indirect value applicability and short-term perspective):

- The automation of the (currently manual) check-in and check-out processes each transport grate has to go through when transported. To equip delivery trucks with GPS sensors and grates with BT5.1 sensors would make it possible to recognize when, where and which grates are delivered and taken-back. This would improve the process speed and, indirectly, affect its cost;
- The optimization of the material flow within the warehouse. To equip a pool of grates with BT5.1 sensors would make it possible to study their usual movements within the warehouse. This would improve the process speed and, indirectly, affect its cost.

On the other hand, the discussion touched on novel issues – to be addressed in future applications or extending the obtained learnings - that emerged during the project and that directly affected its performance objective (i.e. in Figure 6: new efficiency opportunities, direct value applicability and long-term perspective):

- The elimination of the (currently manual) order labelling on the grates and the related need (and cost) for dedicated resources (i.e. man-hours), as each grate would be identifiable by a BT5.1 tag: it would hence be possible to build a more comprehensive IT system that digitally matches the grate to a specific customer order;

After that, according to the “digital transformation focus-shift” theoretical framework, the discussion was focused on how these learnings and their additional applications (i.e. extended potential) could have supported further innovation projects, part of the current company strategy (i.e. innovation). This discussion highlighted the following possibilities (Figure 6):

- The introduction of autonomous guided vehicles (AGVs) for automating internal logistics, due to the need for precise tracking of the position of the grates, enabled by BT5.1 sensors;
- The introduction of an as-a-service business model to capitalize on the use of the transport grates by competitors, catalyzed by the traceability of the grates at a national level enabled by GPS sensors.

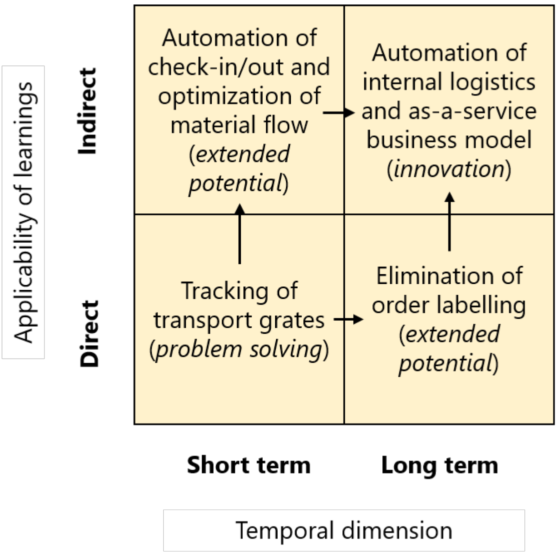

Figure 6 - Final digitalization initiative focus

After the workshop participants had discussed these business opportunities linked to the additional application of the learnings obtained from the digital transformation project, their perception of the technology's business case eventually changed. The company stakeholders organized a second workshop for discussion with the company's top management as well as managers from another plant, which were suffering from the same issues. All the involved stakeholders agreed that, although the business case was perceived as negative when related to the initial problem only (i.e. problem solving, Figure 5), it became interesting once the focus was including the larger applicability spectrum of the developed solutions and of the consequential learnings (i.e. extended potential and innovation, Figure 5). In consequence, the company decided to immediately deploy the first solution (first demonstration case) on a temporary basis, to study the movements of a small batch of transport grates and identify patterns concerning their loss. In addition to that, they decided to further investigate the second solution (second demonstration case) in regards to its additional application cases, to provide additional support to the business case before discussing its potential scaling.

5.4. Validation of the artefact in context

The proposed theoretical framework satisfied both validation criteria (A, applicability and B, effectiveness). Regarding criterion A, the theoretical framework proved to be applicable in an industrial setting as, after the researchers presented it, the company stakeholders adopted it as a starting point for brainstorming the potential applications of the learnings from the digital transformation project. Moreover, they repetitively commented on its usefulness in widening the evaluation perspective when dealing with innovation projects, demonstrating their understanding of the concept behind it. Regarding criterion B, the framework enabled a shift of perception concerning the business case of the digital transformation project due to the consideration of the identified additional business opportunities - both short- and long-terms as well as direct and indirect. These had been included in the updated assessment of the digital transformation project's business case and led to the eventual decision to proceed with the project.

6. Discussion

The industrial case engaged for the testing of the proposed theoretical framework provided a tangible example of how the presence of an unclear business case – and, more importantly, its perception as a negative one - acts as a barrier for the adoption of digital technologies. Thus, the case provided three central findings. First, unexpected novel business opportunities emerge over time in digital innovation projects. Second, these business opportunities can be identified and articulated through leanings obtained from the innovation project itself - thus increasing the firm's sensing capabilities. Third, these increased sensing capabilities change managers' perception of the technology's business case.

The testing of the "digital transformation focus shift" framework in the industrial case highlighted how the theoretical framework facilitated the recognition of multiple business opportunities, thus increasing the firm's sensing capability. While the hidden value potentially of innovation is widely documented in both the I4.0 literature (Cimini et al., 2020; Demeter et al., 2020; Ghobakhloo, 2018) and general innovation literature (Paulson et al., 2007; Rice et al., 2001), the successful use of a model to facilitate their recognition starting from the obtained learnings (i.e. the theoretical framework we proposed in section 4) was only hypothetical. We showed that those learnings and their reflection in managerial decision-making are key to increase the management's ability to sense and shape opportunities. Specifically, we showed that our framework expanded managers' focus beyond a direct problem solving perspective, thus enabling them to scan a broader temporal and locational horizon, and to articulate opportunities beyond immediate concerns – in line with qualities that Teece (2007) posited as central to strong sensing capabilities. Thus, we contributed to the growing literature on Industry 4.0 adoption as strategic process that relies on social and organizational aspects just as much as on technological or structural considerations (Cimini et al., 2020; Frank et al., 2019).

For practice, the proposed "digital transformation focus shift" framework provides innovators – often technologists without experience in recognizing business opportunities (Rice et al., 2001) – a tool to identify and communicate the "hidden" potential of an innovation project to the firm's decision makers. Thus, instead of force-fitting digital innovations into the tight corset of conventional business cases, we have provided a conversational tool building on the logic of reframing (Raffaelli et al., 2019). We have shown that the framework expands the perceived innovation boundaries widening the assessment horizon concerning innovation projects. Given the current collimation between innovation projects and digital transformation ones, we could affirm that this theoretical framework is supporting companies in succeeding in their digital transformation projects by supporting their business cases, addressing what was identified by Schmitz et al. (2019) as one of their main barriers for the digital transformation of manufacturing companies. Illustrating the potential, one of the authors has adopted the framework for his own consultancy practice to structure the dialog with customers' in the early stages of technology innovation projects, thus successfully facilitating identifications of further potential business opportunities. Moreover, he uses the framework as a communication tool to present the outcome of such studies to customers' top management, responsible for allocating the funding for the innovation project.

Our proposed theoretical framework provides a novel approach to support explorative innovation initiatives that are challenged from the point of view of conventional business cases. However, for the frameworks successfully operationalization, and to effectively increase the firm's sensing capability, two conditions must be met. First, the involved stakeholders must understand the operations the innovation initiative is addressing, as well as the company's strategy. This contextualization is necessary for the identification of additional applications of the obtained learnings for either solving additional problems (i.e. extended potential) or supporting further innovation (i.e. innovation). Second, the framework requires recurring consideration of potential innovation outcomes in context of newly gathered learnings and insights. This requirement is mirrored in previous findings that found a positive influence of agile or lean organizational structures – built on iterative and learning-oriented routines – on the success of I4.0 adoptions (e.g. Cimini et al., 2020; Ghobakhloo and Fathi, 2019).

As a qualitative single case study, we need to be cautious regarding the generalization of our insights. Specifically, the development of the artefact through repeated interaction with the company practitioners might have added to their learning beyond the effect that the final artefact might have in context that had not contributed to its development. While one of the authors has since successfully applied the framework in his consultancy practice, we have no systematic data on the general applicability of the framework for I4.0 strategies in other firms. Specifically, we lack insight whether the success of the framework may be contingent on certain characteristics of the firm, which could enable a more or less fruitful conversation about "value potentialities". Moreover, while in the present case the firm decided to pursue the identified opportunities, we cannot conclude that this would be the case for any company. For example, companies with limited resources might decide against seizing opportunities, even if the framework might enable them to see the long-term potentiality of the opportunity. Thus, further research could address how interventions building on our framework affects the development of sensing *and* seizing capabilities in different organizational contexts.

7. CONCLUSION

The industrial digital transformation agenda catalyzes a plethora of innovation projects, often concerning the introduction of new technologies. One of the key, non-technical barriers for the implementation of digital innovations concerns the translation of such activities into a clear - and positive - business case for the company. However, as we have shown, the absence of a perceived clear business case may often be grounded in a firm's limited sensing capability, blinding them to perceive opportunities beyond the direct and short term benefits of a technology.

To address this need and support digital transformation projects succeeding, we proposed a theory-derived framework – the "digital transformation focus-shift" framework. The framework structures and supports the identification of business opportunities linked to (and enabled by) the learnings obtained from digital transformation projects. By guiding the identification and formulation of the potential exploitative value of exploratory projects into specific project proposals, it aims to support decision-makers in broadening their perspective when evaluating a business case. We tested the framework in an industrial setting and observed both its applicability and its role in facilitating innovators and managers in the identification of additional business opportunities linked to an innovation project. The case showed how continuous reflection on learnings from an originally narrowly scoped technical projects enabled management and innovators to sense novel opportunities for value creation. The inclusion of these business opportunities in the innovation's initiative outcome led the company's stakeholders to change their perception concerning its business case, and convinced us of the validity – and value – of the proposed theoretical framework.

The application of the theoretical framework in the presented case study gave a first glimpse of its usefulness for broadening the value appraisal of digital innovation projects. We hope that through further application in other industrial settings with further iterations the model can be refined regarding its wider and more generalizable application. Such, we see its potential to be developed into a set of useful tools that enable manufacturers to confidently embark on the digital journey and harvest the promised benefits of new technologies.

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